

# THE NAUTILOID *BRACHYCYCLOCERAS* IN THE UPPER CARBONIFEROUS OF BRITAIN

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**ABSTRACT.** The nautiloid genus *Brachycycloceras*, known from Pennsylvanian sediments in the U.S.A., occurs rarely in the British Isles where it is represented by two species *B. koninckianum* (d'Orbigny) and *B. obtusum* (Brown). These two species are re-described and synonymies suggested. The distinctions between *Brachycycloceras*, *Reticycloceras*, *Cornuella*, and *Perigramnoceras* are discussed briefly.

*BRACHYCYCLOCERAS* is a relatively well known orthoconic nautiloid in the Pennsylvanian rocks of the United States of America. Its occurrence in the Upper Carboniferous of the British Isles has not been widely recognized, hitherto. Previous references in the British literature to this genus have been to *Orthoceras koninckianum* d'Orbigny and *O. obtusum* Brown. Neither of these two species was included by Miller *et al.* (1933), nor by Furnish *et al.* (1962) in their descriptions of *Brachycycloceras*.

In this paper the affinities of *Brachycycloceras* to morphologically similar Carboniferous genera are briefly discussed. These include *Reticycloceras* Gordon, 1960; *Cycloceras* M'Coy, 1844 (= ?*Perigramnoceras* Foerste, 1924); and *Cornuella* Shimansky, 1968. The two British species of *Brachycycloceras*, *B. koninckianum* (d'Orbigny) and *B. obtusum* (Brown) are re-described and illustrated, and their affinities with North American species are discussed. Knowledge of the genus in the British Isles is limited by the paucity of suitably preserved specimens.

## SYSTEMATIC PALAEOLOGY

Superfamily ORTHOCERATACEAE M'Coy, 1844

Family BRACHYCYCLOCERATIDAE Furnish, Glenister and Hansman, 1962

Genus BRACHYCYCLOCERAS Miller, Dunbar and Condra 1933

*Type species.* *Brachycycloceras normale* Miller, Dunbar and Condra, 1933 (? = *Orthoceratites koninckianum* d'Orbigny, 1850).

*Diagnosis.* Moderately large nautiloids consisting of rapidly expanding orthoconic to weakly cyrtoconic, exogastric, longiconic deciduous shell and breviconic truncated mature conch. Deciduous portion circular to quadrate in cross-section, strongly annulate, shell surface finely liriate; mature shell, weakly annulate to non annulate with liriate surface ornament. Mature shell with internal dorsal and dorso-lateral transverse thickened ridge and prominent bilobate muscle scars. Septa thin, directly transverse in deciduous portion but strongly directed to the anterior, dorsally in mature conch. Siphuncle between centre and venter, septal necks questionably suborthochoanitic.

*Discussion.* The genus was introduced by Miller *et al.* (1933) for a group of Pennsylvanian nautiloids distinguished by a rapidly expanding (1 in 3 to 5) orthoconic shell with subquadrate cross-section, irregularly spaced, prominent, sinuous annuli, and a finely liriate surface, represented by *B. normale* n. sp., *B. crebricinctum* (Girty), and *B. kentuckiense* n. sp. Including these latter species in the synonymy of *B. normale*, Furnish *et al.* (1962) were able to show specimens exhibiting an abrupt increase in the rate of expansion of the shell at a thickened septum of truncation on the formation of a breviconic ascoceroid-like mature body chamber. The siphuncle, situated between centre and venter, is said to have suborthochoanitic septal necks. The internal characters of the genus have not been well

illustrated, and the observations made here are limited also by the paucity of British material and its preservation.

*Brachycycloceras* appears to be uncommon in Britain. The present account is based on examination of approximately twenty-four specimens in the collections of the British Museum (Natural History), the British Geological Survey, and the Manchester Museum. All the specimens of deciduous shell are fragmentary, lacking apical parts, and none shows the abrupt expansion into mature body chamber as illustrated by Furnish *et al.* (1962, pl. 179, figs. 2, 3). Shell truncation may have occurred more than once in the animal's development, but this cannot be demonstrated from the material available here.

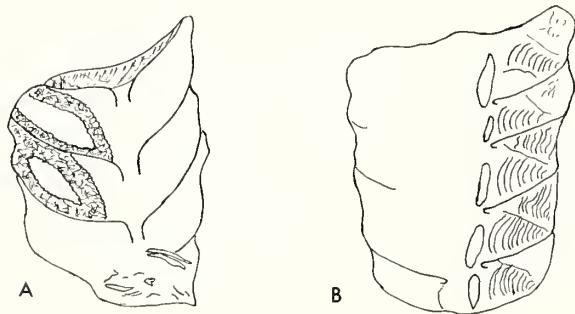
All except one of the mature body chamber specimens are referable to *O. obtusum* Brown. There is some resemblance to the type of *B. curtum* (Meek and Worthen), though the ventral expansion is not as great as that shown in plate 180, figure 3 of Furnish *et al.* (1962). One specimen (Pl. 24, figs. 6-8, 10) shows greater similarity to the mature *B. bransonii* (Miller and Owen) (Furnish *et al.* (1962), pl. 180, fig. 9), but it is only half the size. The deciduous portions of shell examined represent only the single species *B. koninckianum*, unless the interpretation of Phillips's figured specimens of *O. reticulatum* as pathological and *O. annulatum* as *Reticycloceras*, here given, is incorrect.

The information available on the age of the genus indicates a Namurian (E2) to Lower Westphalian A (G2) range. Records of specimens from the Dukinfield Marine Band, Westphalian B (Wright 1931, p. 148), and the Viséan P2 (Stephens *et al.* 1953, p. 12) are suspected of being misidentifications, though the specimens were not available for examination by the author.

The many unanswered questions concerning the genus *Brachycycloceras* are likely to remain until additional well-preserved and localized material is available for study.

*Affinities.* There seems to be sufficient variation in the external characters of the annulate orthocones that occur in the British Carboniferous, to enable distinction to be made between *Brachycycloceras*, *Reticycloceras* Gordon, 1960, '*Cycloceras*' M'Coy, 1844, and *Cornuella* Shimansky, 1968.

In *Reticycloceras*, the shell expands at a slower rate of 1 in 6.5 to 7.5. The cross-section is circular. Five to seven regularly spaced, sharply rounded annuli are present in a length equal to the diameter. They are slightly oblique to the long axis. The surface of the shell is coarsely lirate transversely and the juvenile shell is also longitudinally lirate before the appearance of pronounced annulation, producing a reticulate ornament (Pl. 25, fig. 1). This last feature is of doubtful significance generically, since fine reticulate ornament is present on the juvenile parts of several different nautiloid genera throughout the geological column. The siphuncle is subcentral, suborthochoanitic to weakly cyrtochoanitic with subcylindrical connecting rings (text-fig. 1B).



TEXT-FIG. 1. Drawings of median dorso-ventral sections. A, ?*Brachycycloceras* sp. BMNH C181. Apical part of specimen figured Plate 25, figs. 4-7,  $\times 3$ . B, apical part of *Reticycloceras* sp. BMNH C31867,  $\times 6$ . Carboniferous, Scotland.

The form commonly referred to *Cycloceras* or *Perigrammoceras*, i.e. *O. laevigatum* M'Coy (Foord (1897), p. 14, pl. 15, fig. 1d, e) is a gradually expanding (1 in 26) shell with a circular cross-section and a centrally situated orthochoanitic siphuncle. The annuli are prominent, broadly rounded, regularly spaced, directly transverse to the long axis, and without sinuosity. The surface is transversely lirate.

In *Cornuella* (e.g. BMNH 80385, C2884, C81323) the rate of expansion is about 1 in 6 and the shell is slightly cyrtocoenic with a circular cross-section. The annuli are somewhat oblique to the long axis but without sinuosity, well rounded in cross-section and ribbed longitudinally.

*Brachycycloceras koninckianum* (d'Orbigny, 1850)

- 1844 *Orthoceras anceps* de Koninck, p. 517, pl. 45, fig. 7a, b (non Münster 1840).  
 1850 *Orthoceratites koninckianum* d'Orbigny, p. 113.  
 1905 *Orthoceras koninckianum* d'Orbigny; Hind, p. 111, pl. 5, fig. 22.  
 ?1933 *Brachycycloceras kentuckiense* Miller, Dunbar and Condra, pl. 3, figs. 1, 2.  
 ?1933 *Brachycycloceras normale* Miller, Dunbar and Condra, pl. 3, figs. 3-5.  
 ?1962 *Brachycycloceras normale* Miller, Dunbar and Condra; Furnish, Glenister and Hansman, pl. 179, figs. 2-4; pl. 180, figs. 7-8.

*Holotype*. The specimen figured in pl. 45, fig. 7a, b of de Koninck (1844).

*Material*. Nine specimens in BMNH Coll. C5272, C27460, C28456, C78412, C78413, C78414, C85233-85234, C85235. Eight specimens in MM L10027, L10792a-g. Two specimens in B.G.S. 82288, XIII/6/11.

*Diagnosis*. *Brachycycloceras* with a rapidly expanding (1 in 3) annulate orthocone. Annuli prominent, obtusely rounded, almost directly transverse to long axis with shallow lateral sinuses. The interval between annuli is somewhat irregular, usually four annuli in a length equal to diameter. Shell slightly quadrate in cross-section. Exterior surface of shell finely lirate transversely. The siphuncle is situated between centre and venter.

*Discussion*. The specific name was introduced by d'Orbigny to replace *O. anceps* de Koninck, a name preoccupied by Münster (1840). This species was not referred to by Miller *et al.* (1933) when establishing the genus *Brachycycloceras*, nor by Furnish *et al.* (1962). De Koninck's figure, reproduced here (Pl. 25, fig. 16) appears to show external features typical of *B. normale*, and the two are probably conspecific.

Apart from a poorly preserved, crushed specimen in shale (C85235), the British specimens in the BMNH collection are all solid fragments of deciduous portions of the shell. They range in size from a half diameter fragment of 15 mm in length to a specimen 40 mm in length (C85233). None of these specimens shows evidence of the accelerated expansion of the shell at the formation of the mature conch, nor of the adapical part of the shell below a diameter of 9 mm. A juvenile specimen from Chokier, Belgium (BMNH 64813) with a minimum diameter of 3 mm, shows an abrupt increase in the rate of expansion at the appearance of annulation (Pl. 25, figs. 2, 3). No extreme apical parts are available to show if reticulate ornament was present as in *Reticycloceras* (Pl. 25, fig. 1). Longitudinal striation can be seen, in some specimens, on the crests of the dorso-lateral parts of the annuli (e.g. C78413) that are thought to be evidence of former muscle attachment areas. They can be seen on the specimen of *O. reticulatum* figured by Phillips (1836, pl. 21, fig. 11), and may be the 'reticulation with moniliform lines' to which he refers, but that Foord (1888, p. 108) thought 'cannot now be made out'. Comparable muscle scars are well seen in BMNH C75834 (Pl. 24, figs. 6-8) referred to under *B. obtusum*. In some specimens a conchal and/or dorsal furrow is well shown.

The fine liration of the shell exterior follows the same direction as the annuli. In some specimens (e.g. MM L10792a, Pl. 25, fig. 12) parts of the lirae overrun previously formed ones in parabolae as in *Neorthoceras* (see Sweet 1964, p. K258, text-fig. 186: 5b). This feature is seen in several orthoceratids of different ages and is probably evidence of repair of shell damage.

The septa of *B. koninckianum* appear to have been thin and fragile. Most of the specimens seen are non-septate body chamber fragments filled with shell debris and juvenile goniatites (e.g. BMNH C78412). Phillips's *O. reticulatum* (1836, pl. 21, fig. 11), here refigured (Pl. 25, figs. 4-7) is a septate specimen. A drawing of the dorso-lateral median section of its apical part is here reproduced as text-figure 1A and shows longer than average orthochoanitic septal necks, though *Brachycycloceras* is said to be suborthochoanitic. The rate of expansion in this specimen (1 in 6) is close to that of *B. longulum* Miller and Owen (1934), but the annulation is closer to that of *B. koninckianum*. However, since the

dorsal and conchal furrows preserved on this specimen are not in one plane (Pl. 25, fig. 7), it is possibly a pathological example and not reliable evidence for the internal structure of the genus.

Another of Phillips's figured specimens, *O. annulatum* (1836, pl. 21, fig. 10) is here refigured (Pl. 25, figs. 8-10). It was referred to by Furnish *et al.* (1962, p. 1347) and shows a superficial resemblance to their pl. 179, figs. 11, 12, showing *B. curtum*. On closer examination this specimen shows fractures indicating that its apparent cyrtoconic form and its rapid expansion are the results of distortion due to crushing of an originally orthoconic shell. The annulations are more numerous, more regularly spaced, and more acute than in *Brachycycloceras*, and lack the characteristic lateral sinuses. It is possibly a species of *Reticycloceras*.

The specimen here figured as Plate 25, fig. 15 is the original of Hind (1905, pl. 5, fig. 22: *O. koninckianum*). The true rate of expansion is not seen as the specimen is broken along its length on one side. It probably comes from the upper part of the Foynes Shales of R1 age, and a specimen of *Reticuloceras reticulatum* (Phillips) is in the same piece of matrix. Most of the other specimens seen are poorly documented in respect of horizon and locality, but with the help of published references to *O. koninckianum* it is evident that the species ranges throughout the Namurian from E2. A specimen seen by the writer (F1231, C. P. Eardly Coll., Stoke Museum) came from the roof of the Crabtree Coal at Werrington Colliery, Stoke-on-Trent, indicating a lower Westphalian A, G2 age. Specimens of *O. koninckianum* recorded by Wright (1931, p. 148) (LT 1707-1773) from as high as the Dukinfield Marine Band (i.e. Westphalian B) were not located by the writer in the BGS Collection. Other specimens, not found, were recorded from Viséan P2 strata (Stephens *et al.* 1953, p. 12), but are possibly misidentified specimens of the group of '*O. laevigatum*' M'Coy.

#### *Brachycycloceras obtusum* Brown, 1841

- 1841 *Orthoceras obtusum* Brown, p. 219, pl. 7, fig. 36.  
 1938 *Orthoceras dilatatum* de Koninck; Demanet, p. 166, pl. 126, fig. 1.  
 non 1941 *Brachycycloceras dilatatum* (de Koninck); Demanet, p. 113, pl. 4, fig. 3.

*Holotype.* The specimen figured by Brown (1841, pl. 7, fig. 36) in the Manchester Museum L10026.

*Material.* BMNH C5276, C78415, C5271, C82538; BGS BB4178; MM L10027.

*Diagnosis.* *Brachycycloceras* with a slightly depressed brevicone, expanding from deeply rounded basal septum at a rate of 1 in 3 viewed ventrally and 1 in 4 viewed laterally. Contracting adorally to produce an ovoid shell. Surface non-annulate, with fine transverse lirae that form shallow sinuses laterally. Ornament becoming coarser and imbricate adorally. Septa directed sharply anteriorly in a broad saddle on the dorsum.

*Discussion.* The holotype (Pl. 24, figs. 1, 2) is the adapical portion of a mature body chamber that is abraded and crushed on the dorsal side. More completely preserved specimens (e.g. Pl. 24, fig. 4) show that slight contraction occurred adorally, producing a somewhat ovoid shape. None of the specimens shows more than two septa, and none shows the complete suture line clearly. Demanet (1938, p. 166, pl. 126, fig. 1) figured an example of this species as *O. dilatatum* de Koninck, and listed it

#### EXPLANATION OF PLATE 24

- Figs. 1, 2. Holotype of *Orthoceras obtusum* Brown (1841, pl. 7, fig. 36). Manchester Museum L10026. Carboniferous, Hebden Bridge, Halifax, Yorkshire,  $\times 1.5$ . 1, ventral view. 2, lateral view.  
 Fig. 3. *Brachycycloceras ?obtusum* (Brown). BMNH C5271. Hebden Bridge, Halifax, Yorkshire,  $\times 1$ .  
 Figs. 4, 5, 9. *Brachycycloceras obtusum* (Brown). BMNH C5276. Carboniferous, nr. Halifax, Yorkshire,  $\times 1$ . 4, ventral view. 5, lateral view. 9, apical view.  
 Figs. 6-8, 10. *Brachycycloceras* sp. BMNH C75834. Carboniferous, G1, Bankhall Colliery, Burnley, Lancashire. The periphraet and retractor muscle areas have been outlined. 6, muscle scar,  $\times 2$ . 7, dorsal view,  $\times 1$ . 8, lateral view,  $\times 1$ . 10, adoral view,  $\times 1$ .



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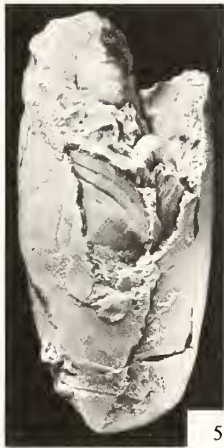
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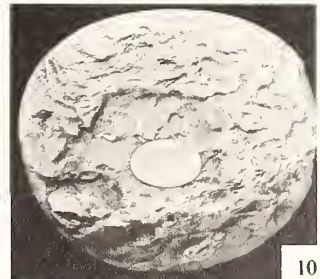
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under the synonymy of *B. dilatatum* in his 1941 work. De Koninck's *O. dilatatum* is, however, a more rapidly expanding shell resembling the *B. curtum* of Furnish *et al.* (1962, pl. 180, figs. 1-4).

The basal septa of these specimens are strongly convex forward on the dorsum (Pl. 24, fig. 5) suggesting that they are mature decollated body chambers. Evidence for their inclusion in *Brachycycloceras* is poor in the absence of associated deciduous parts, but the lirate ornament of the shell is typical of that genus. One specimen (Pl. 24, fig. 3) that is probably referable to *B. obtusum* apparently shows a transition from strongly annulate deciduous shell to non-annulate mature body chamber with evidence of finely lirate ornament.

A different type of mature body chamber is shown by one specimen in the BMNH collection, C75834 (Pl. 24, figs. 6-8, 10). It shows closer resemblance to the *B. bransoni* (Miller and Owen) figured by Furnish *et al.* (1962, pl. 180, fig. 9) than to *B. obtusum*, though much smaller in size. It is a slightly depressed brevicone, expanding from 26 mm to 40 mm diameter in the lateral plane, and 24 mm to 35 mm dorso-ventrally, in a length of 60 mm. No evidence of annulation or surface ornament is preserved. The apex is damaged and obscured by matrix but the course of the suture can be made out. It is transverse across the venter and swings sharply forward on the lateral areas to form a broad, high saddle on the dorsum. Anterior of the apical septum, a dark brown band, 2 mm in width, encircles the shell parallel to the course of the septum, expanding on the dorso-lateral margins in small sub-ovoid areas with a conchiolin-like surface, slightly furrowed at the anterior margins. This is interpreted as representing the periphraet and retractor muscle areas of attachment. A broad, shallow constriction runs transversely near the anterior margin dorsally, fading out dorso-laterally, indicating a corresponding thickened internal ridge of the shell.

The affinities of all these body chambers remains speculative in the absence of further well-preserved material, particularly of specimens showing deciduous and mature parts in association. Detailed horizon and locality information is also lacking for the *B. obtusum* specimens seen. Using published references—e.g. Wray *et al.* (1930, p. 34); Stephens *et al.* (1941, pp. 355, 360)—it can be seen that they occur through R1 and R2. BMNH C75834 is from the Union Mine Seam (i.e. G1), and a specimen is recorded by Stephens *et al.* (1953, p. 77) from the Pot Clay Marine Band (i.e. G2).

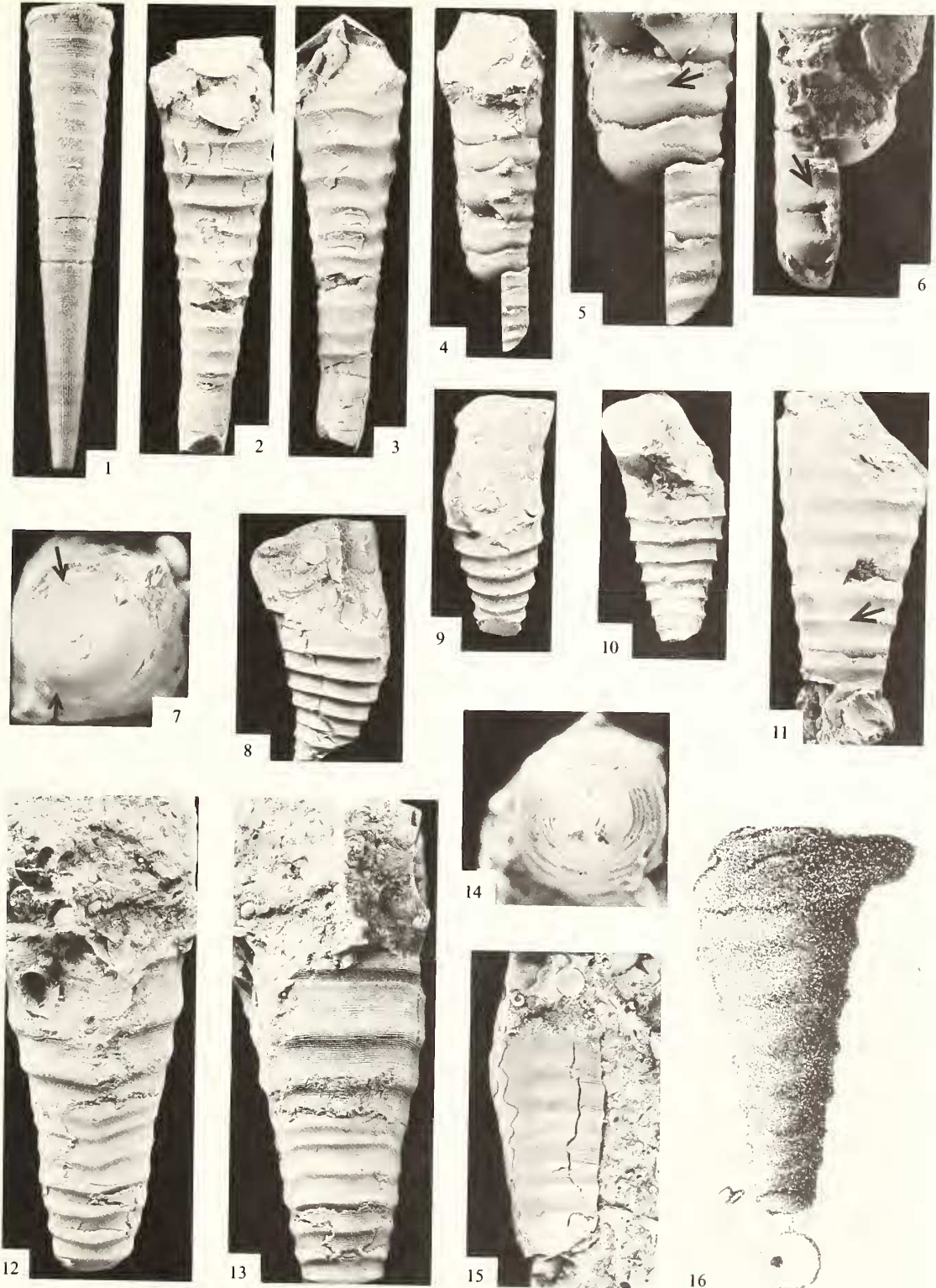
## CONCLUSIONS

In Britain, examples of the nautiloid genus *Brachycycloceras* are of rare occurrence in Namurian and Westphalian A strata. The genus is recorded from higher levels in the succession in the U.S.A., being

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### EXPLANATION OF PLATE 25

- Fig. 1. *Retiycloceras* sp. juv. BMNH C71861. Carboniferous, nr. Dunfermline, Scotland,  $\times 3$ .  
 Figs. 2, 3. *Brachycycloceras koninckianum* (d'Orbigny). BMNH 64813. Carboniferous, étage Houiller H, Chokier, Belgium,  $\times 2$ .  
 Figs. 4-7. ?*Brachycycloceras* sp. BMNH C181 (= holotype of *Orthoceras reticulatum* Phillips, 1836, pl. 21, fig. 11). Carboniferous, Bolland, Yorkshire. Arrows indicate conchal and dorsal furrows. 4, ventral view,  $\times 1$ . 5, ventral view showing conchal furrow,  $\times 2$ . 6, dorsal view showing dorsal furrow,  $\times 2$ . 7, apical view, venter uppermost,  $\times 2$ .  
 Figs. 8-10. ?*Retiycloceras* sp. BMNH C206 (= *O. annulatum* Phillips, 1836, pl. 21, fig. 10). Carboniferous, locality unrecorded,  $\times 1$ .  
 Fig. 11. Ventral view of *Brachycycloceras koninckianum* (d'Orbigny) showing conchal furrows (arrowed). Manchester Museum L10792b. Carboniferous, nr. Halifax, Yorkshire,  $\times 1.2$ .  
 Figs. 12-14. *Brachycycloceras koninckianum* (d'Orbigny). Manchester Museum L10792a. Carboniferous, nr. Halifax, Yorkshire,  $\times 2$ . 12, lateral view, parabolic ribbing shown on the adoral annulation. 13, ventral view. 14, apical view.  
 Fig. 15. *Brachycycloceras koninckianum* (d'Orbigny). BMNH C28456 (figured Hind (1905), pl. 5, fig. 22). Carboniferous, R1, Foynes Island, Co. Limerick, Eire,  $\times 1$ .  
 Fig. 16. *Orthoceras anceps* as illustrated by de Koninck (1844, pl. 45, fig. 7a, b).



moderately abundant in Middle and Upper Pennsylvanian rocks. Fayetteville Shale (= Lower Namurian) specimens are described as *B. washingtonense* by Gordon (1964). Insufficient material is currently available from the British Carboniferous to enable a satisfactory delimitation of species, their development, and affinities.

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